Operative Techniques in Thoracic and Cardiovascular Surgery

Repair of Complete Atrioventricular Septal Defects "Single Patch" Technique

Fred A. Crawford, Jr., MD

The first repair of a complete atrioventricular septal defect was performed in 1954 by Lillehei using a single patch technique and controlled cross circulation. Initial results were disappointing with a very high operative mortality and postoperative complications including complete heart block, left ventricular outflow tract obstruction, and persistent or recurrent mitral regurgitation. The single patch technique continues to be frequently utilized with the assistance of cardiopulmonary bypass, moderate hypothermia, and cold blood cardioplegia for myocardial protection. Transesophageal echocardiography is extremely important in assessing the anatomy preoperatively and immediately after the operation is completed. In the single patch technique the common atrioventricular valve is divided into mitral and tricuspid components, and the ventricular septal defect (and subsequently the atrial septal defect) are repaired with a bovine pericardial patch. The leaflets of the newly created left (mitral) and right (tricuspid) valve are resuspended to the pericardial patch, and the "cleft" in the left AV valve is closed with interrupted sutures. Meticulous attention is paid to assuring left AV valve competence. Utilization of these techniques have resulted in a current operative mortality of 2-4% and markedly decreased incidences of LVOT obstruction and complete heart block. Persistent/recurrent mitral regurgitation continues to be a problem in approximately 5-10% of survivors. It is hoped that further refinements of operative technique will result in a decrease in such mitral regurgitation.

KEYWORDS AV canal, AV septal defect, single patch technique

The first successful correction of a complete atrioventricular septal defect was performed on a 17-month-old girl on August 6, 1954 by Lillehi and associates, using controlled cross circulation.[1] However, for the next two decades, attempted correction of this complex congenital heart defect was associated with poor outcomes including operative mortalities exceeding 20 to 25% and residual defects including persistent shunts, complete heart block, and mitral regurgitation. In recent years, outcomes have improved in part due to improved operative techniques, improved myocardial protection, better understanding of the cardiac anatomy and physiology, and better postoperative management. For many years, the most frequently used technique was the "single patch" technique as first described by the Mayo Clinic Group.[2,3] Subsequently, in 1971, Trusler described the "two-patch" technique for repair[4] and for some time there was considerable debate as to which technique was superior. Currently, it is clear that equivalent results may be obtained by either technique and that perhaps the most important factor influencing outcomes is the individual surgeon's skill with whichever technique is preferred. This single patch technique essentially as originally described by the Mayo Clinic Group has been employed at MUSC by this author for the past 25 years.[5]

Patient Selection

Infants are usually diagnosed with a complete AV canal defect in utero or shortly after birth by echocardiography. Catheterization is rarely utilized today as a part of the preoperative evaluation. Surgical correction is usually scheduled electively at about three months of age, with the youngest patient in our series being five weeks and weighing 2.1 kg.

Department of Surgery, Medical University of South Carolina, Charleston, SC.

Address reprint requests to Fred A. Crawford, Jr., MD, Medical University of South Carolina, Department of Surgery, 96 Jonathan Lucas Street, Suite 409 CSB, PO Box 250612, Charleston, SC 29425; e-mail: crawfrdf@musc.edu

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Intraoperative Management

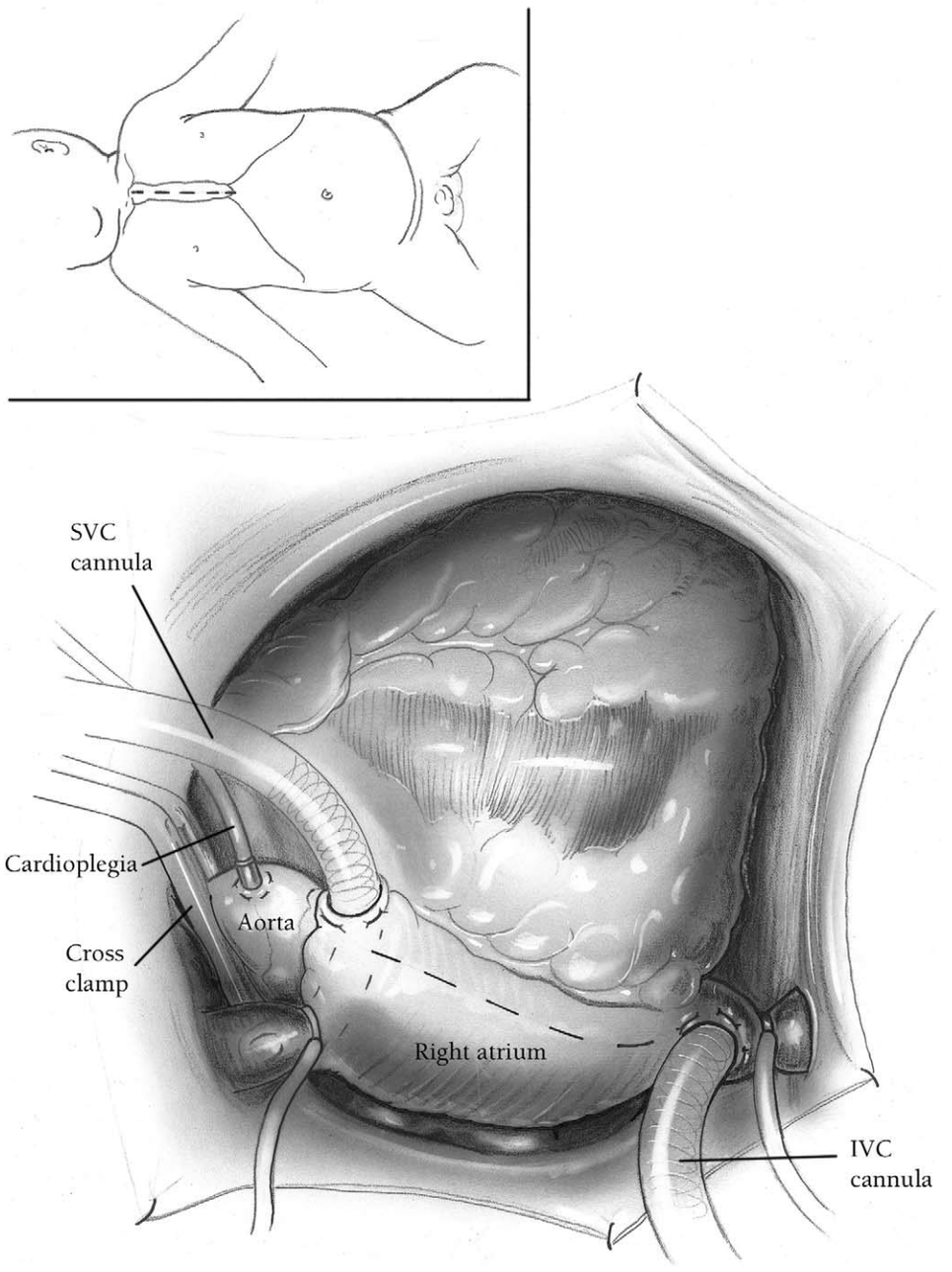

Figure 1 Patients are positioned supine on the operating table and appropriate arterial and central venous catheters are inserted percutaneously. In our series, the heart has usually been exposed through a midline sternotomy incision, but more recently some patients have been operated on through limited skin incisions using a partial lower sternotomy. For this article, all illustrations demonstrate a full sternotomy incision. Fig. 1 depicts a patient cannulated in preparation for cardiopulmonary bypass. The superior vena cava may be cannulated through the right atrial appendage as demonstrated (author's preference) or may be cannulated directly. The IVC is cannulated low at the junction of the RA and IVC. Relatively small venous cannulas may be utilized in conjunction with vacuum-assisted venous drainage. Moderate hypothermia (usually 30 to 32°C) is utilized and circulatory arrest has not been employed in any patient. Myocardial protection is obtained with multi-dose 4°C blood cardioplegia initiated through a cannula in the aortic root as shown. Subsequent doses are provided either through that cannula or through a small retrograde cannula inserted directly into the coronary sinus. The dotted line indicates the proposed site of the right atriotomy incision. When present, a patent ductus arteriosus is ligated just before initiation of cardiopulmonary bypass or as bypass is begun.

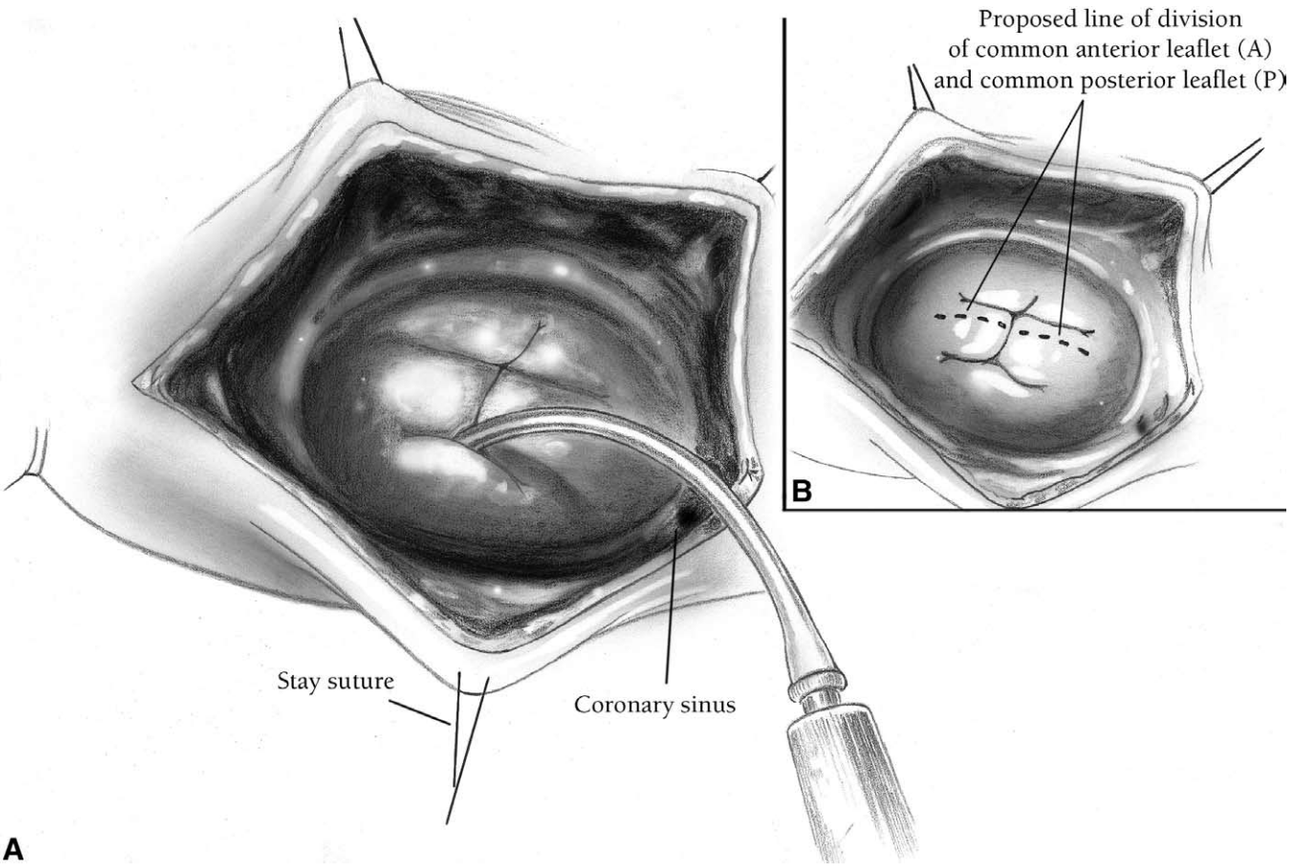

Figure 2 A generous right atriotomy incision is made and exposure is maintained by judicious placement of stay sutures. The superior myocardial protection provided by multi-dose blood cardioplegia permits a detailed and unhurried assessment of the unique anatomy of each patient. When small associated ASDs (or PFOs) are identified, they are usually closed separately. With large ASDs separated from the AV septal defect by a bridge of tissue, this bridge is usually divided and the entire atrial defect closed with the patch as will be described. Once excellent exposure is obtained, the anatomy is carefully assessed with the heart collapsed and the common AV valve open and also following gentle distention of the ventricles with saline.

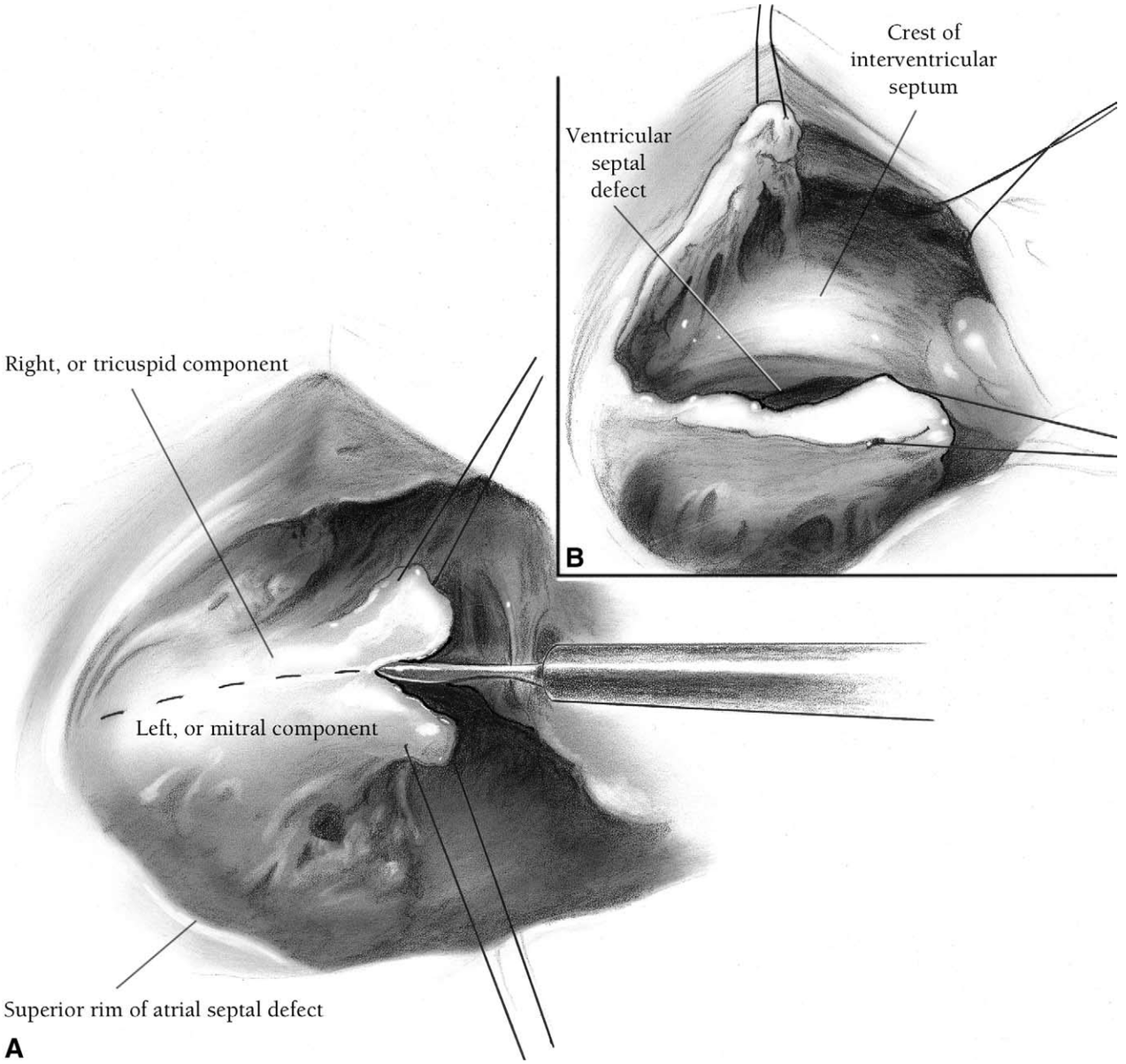

Figure 3 Since the common anterior and posterior leaflets of the common AV valve must be divided in the single patch technique, it is absolutely essential that the points of apposition of these valves first be identified and carefully marked with stay sutures of fine monofilament suture for future reference. This illustration demonstrates a completely undivided anterior leaflet and the dotted line demonstrates the proposed line of division of this leaflet into mitral and tricuspid components. In patients with partially divided anterior and/or posterior leaflets, this process is somewhat simplified as the line of division has already been partially determined. The division extends all the way back to the annulus of the common AV valve. Fig. 3B shows the divided anterior leaflet. Chordal attachments to the crest of the ventricular septum and especially those along the right ventricular aspect of the septum are divided to improve exposure for placing sutures to anchor the ventricular component of the repair patch. Chordae to the free edge of the valve should, however, be carefully preserved.

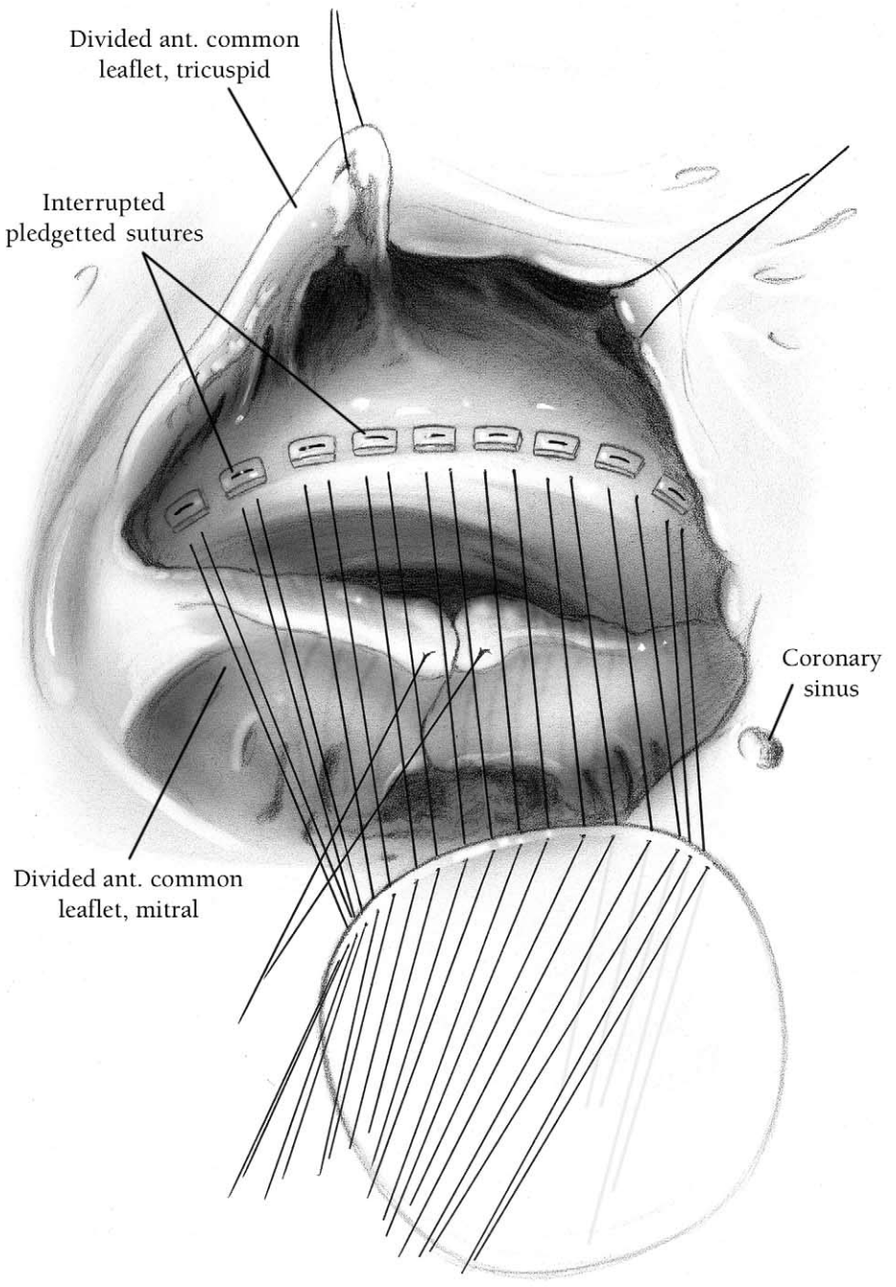

Figure 4 Once leaflet division is completed, multiple interrupted 5-0 braided sutures backed with very small felt pledgets are placed along the right ventricular aspect of the ventricular septum with particular attention paid to the posterior junction of the ventricular septum and the AV valve annulus to avoid injury to the conduction system. These sutures are then passed separately through a single patch of bovine pericardium (Biovascular Inc., St. Paul, MN) which has been washed and cut to the appropriate size and shape. The patch is usually made slightly smaller than the defect to avoid contributing to dilation of the subsequent left AV valve orifice. These sutures anchoring the patch to the ventricular septum are now tied securely.

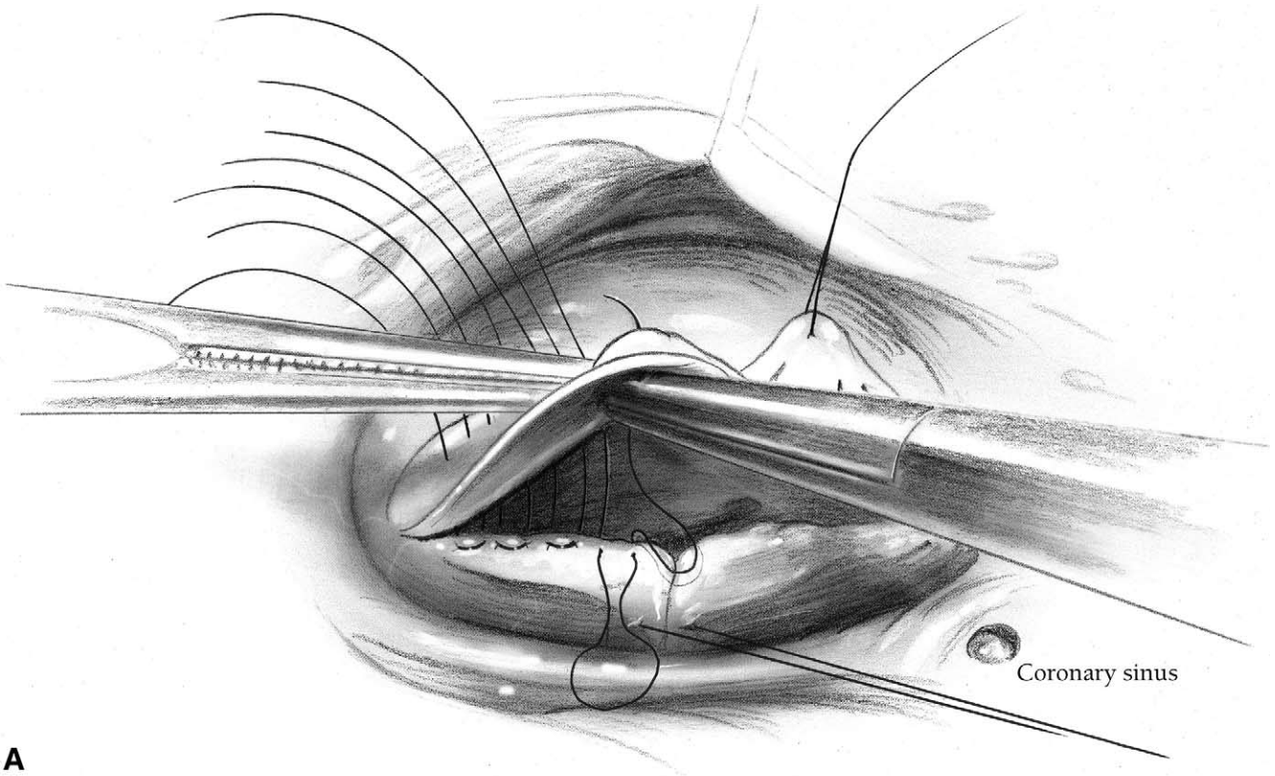

Figure 5 The previously divided valve leaflets are then resuspended to the patch, usually 5 to 10 mm above its attachment to the ventricular septum using multiple 5-0 horizontal mattress sutures which first penetrate the left AV valve leaflet, pass through the pericardial patch and then through the corresponding portion of the right AV valve leaflet. It is during this part of the procedure that initial careful placement of stay sutures is extremely important in aligning the valve leaflets perfectly. By elevating the point of attachment of the valve leaflets 5 to 10 mm above the ventricular septum, it is believed that the potential for postoperative LV outflow tract obstruction is diminished. Fig. 5B shows the completed reattachment of the right AV valve to the patch.

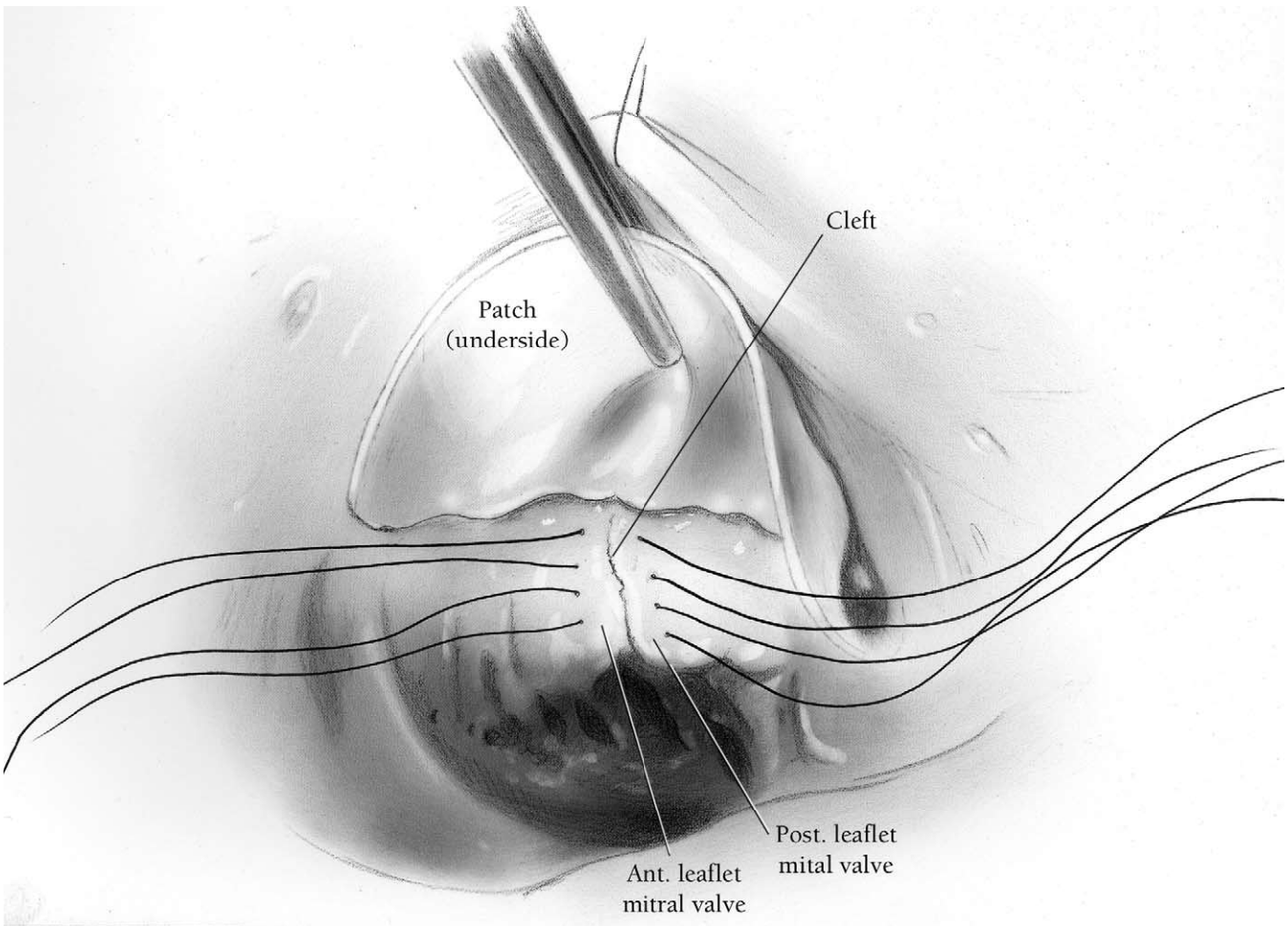

Figure 6 The left (mitral) AV valve is then carefully inspected and the septal commissure ("cleft") is closed at the points of apposition with several interrupted 5-0 sutures. Excessive sutures in this commissure will limit mobility of this valve leaflet and must be avoided, but the cleft should be completely closed.

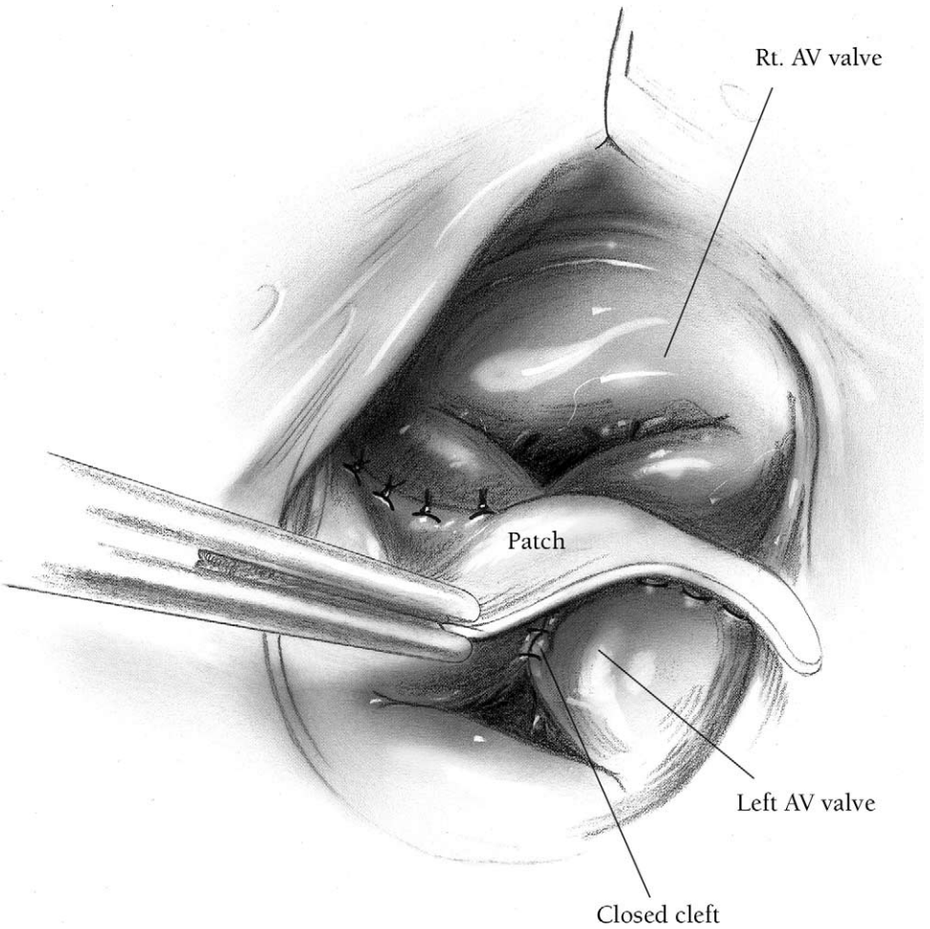

Figure 7 This figure demonstrates complete separate septation of the two ventricles by the patch as well as the construction of a separate left (mitral) and right (tricuspid) valve from the previous common AV valve. The atrial component of the defect has not yet been closed.

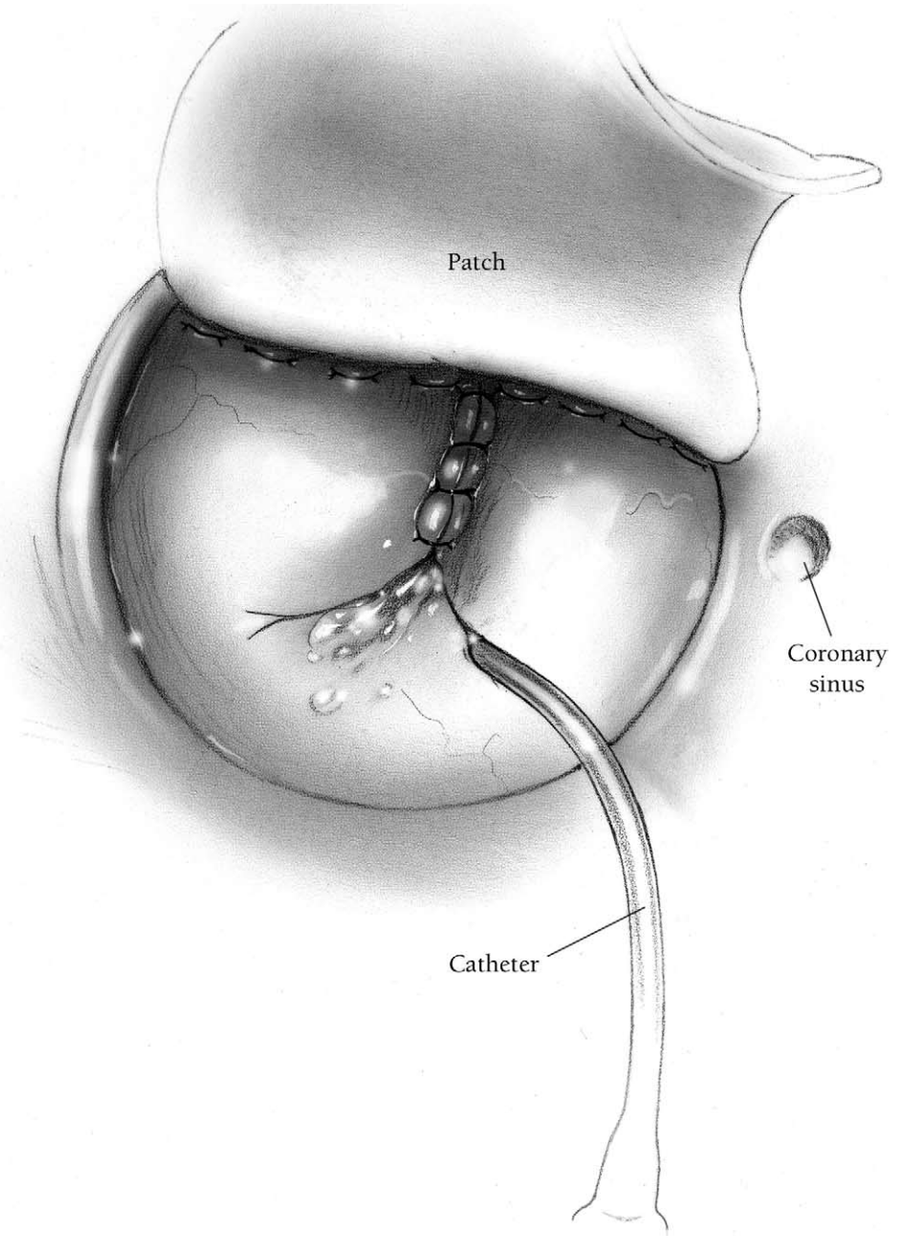

Figure 8 At this point, considerable time is spent assessing the competence of the reconstructed mitral and tricuspid valves. Occasionally adding a suture to the commissural cleft closure or at other times removing a previously placed cleft suture may improve mobility and improve competence. This illustration demonstrates a persistent residual central leak in the left (mitral) AV valve.

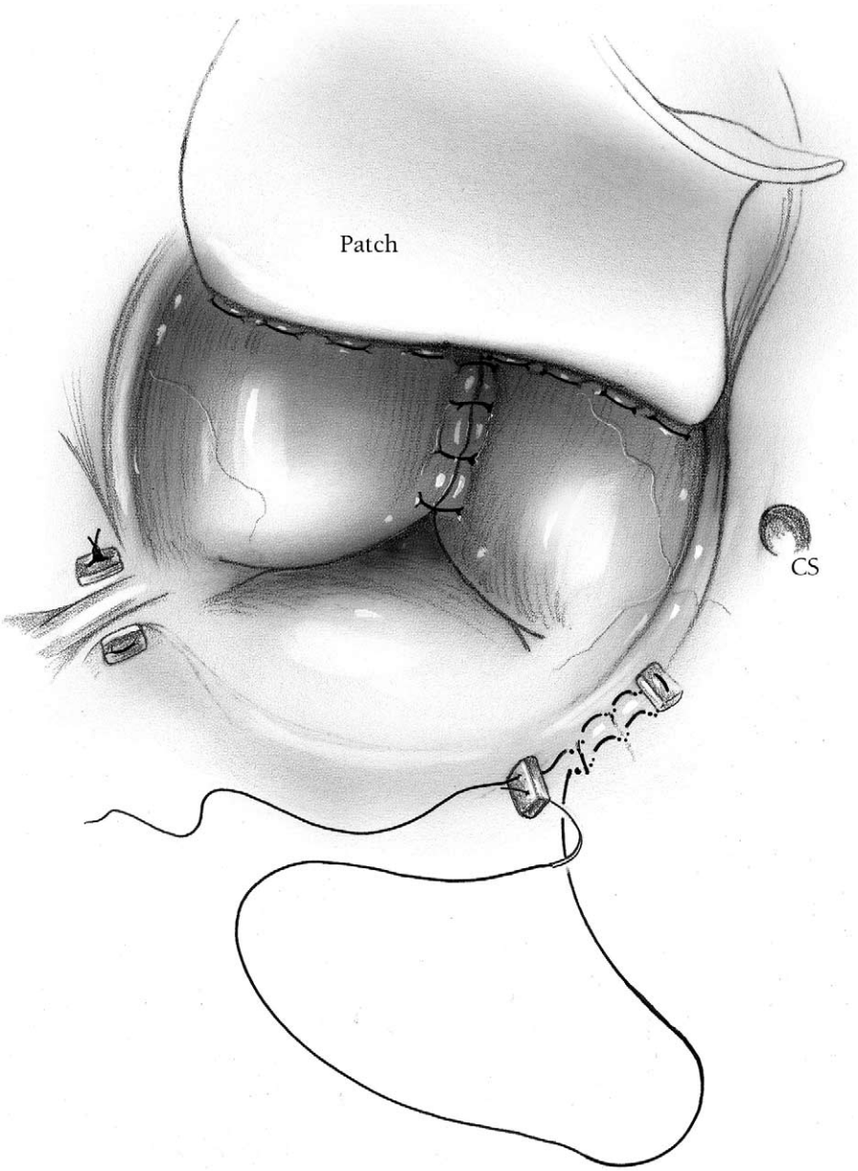

Figure 9 In recent years, we have frequently used annuloplasty sutures as described by Capouya, Laks, and coworkers[6] to slightly diminish the annulus of the left AV valve which in turn allows the existing leaflets to adequately cover the central orifice and prevent central mitral regurgitation. Narrowing the valve orifice so much as to produce obstruction must be carefully avoided by both careful visual inspection and by subsequent assessment with intraoperative transesophageal echo. The steps described in the previous three illustrations represent the most important steps in this procedure, as it is essential to have the best possible repair particularly of the left AV valve to avoid both immediate and late postop AV valve regurgitation and perhaps subsequent reoperation.

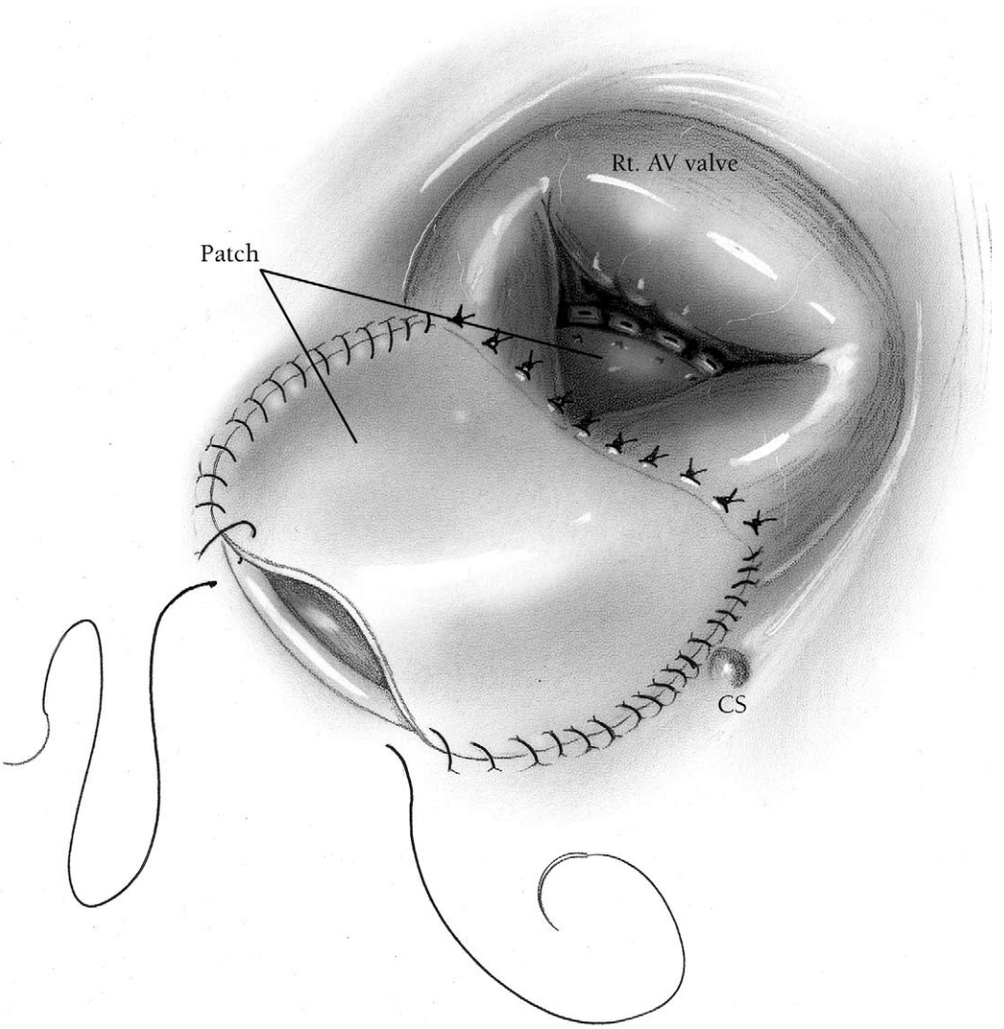

Figure 10 Once the two valves have been carefully assessed and found to be completely competent, the atrial component of the defect is closed by suturing the remaining portion of the pericardial patch which has been cut to the appropriate size and shape to the atrium with a continuous polypropylene suture. The coronary sinus is routinely placed in the right atrium unless this might produce an abnormal deviation of the atrial patch suture line in which case it is allowed to drain into the left atrium. Posteriorly and in the region of the mouth of coronary sinus sutures are placed quite superficially to avoid any possible injury to the conduction system. Following completion of this step, the right atriotomy is closed, the aortic cross clamp removed, cardiac function resumes, and the patient is removed from cardiopulmonary bypass.

All patients are currently assessed by intraoperative transesophageal echo cardiography immediately after hemodynamic stability is obtained following cardiopulmonary bypass. Significant residual AV valve regurgitation requires reinstitution of bypass and further efforts to assure competence. The importance of skilled objective pediatric echocardiographers in the operating room for this assessment cannot be overestimated.

Postoperative Management

Initially, patients underwent extensive physiological monitoring postoperatively utilizing left and right atrial and pulmonary artery catheters. More recently, these catheters have been omitted as they have been found to delay weaning and extubation, thereby prolonging ICU and postoperative stay. Temporary atrial and ventricular pacing wires are placed on all patients. These infants are transferred to a special pediatric cardiothoracic surgical intensive care unit where postoperative management is a joint effort involving the cardiac surgeon, pediatric cardiology intensivists, and specially trained cardiac ICU nurses. Patients who are hemodynamically stable are weaned and extubated as quickly as possible.

Comment

Over the past 10 to 15 years, significantly improved results have been obtained following surgical correction of complete AV septal defects.[5,7,8,9] The larger and better series have demonstrated a steady decline in operative mortality to the range of about 3 to 6%. Since 1990, in the 119 infants in our institution undergoing repair of complete atrioventricular septal defects by the technique previously described, there have been 3 operative deaths for an operative mortality of 2.5%. There have been no operative deaths in the 72 patients operated on since July 1995.

Only one patient (0.8%) required reoperation for left ventricular outflow tract obstruction. The incidence of postoperative complete heart block requiring a pacemaker remains quite low at about 2%. Postoperative low cardiac output has essentially disappeared since cold blood cardioplegia has been utilized for myocardial protection. Ventilator time, ICU length of stay, and overall length of stay have decreased significantly with the decreased use of indwelling cardiac catheters for postoperative physiological monitoring as well as the presence of dedicated pediatric cardiology intensivists in the pediatric cardiac ICU.

Persistent postoperative left AV (mitral) valve regurgitation, however, continues to be a significant problem. Since 1990, 8 patients (7.02%) have required reoperation for residual or recurrent mitral valve regurgitation. Despite careful closure of the cleft in all patients at the time of initial operation, at reoperation, the mitral regurgitation was most often associated with either incomplete closure of the cleft or dehiscence of the cleft closure. Two patients underwent re-repair of the mitral valve during the same admission and both died. Six patients required late reoperation and mitral valve repair, two of whom subsequently required mitral valve replacement. The incidence of reoperation for late mitral regurgitation following repair of a complete AV septal defect by either the single or two-patch technique is remarkably constant in the best series reported since 1990 at about 6 to 8%.[5,7,8,9,10] Because this incidence is so constant in all series utilizing both techniques, one possibility is that 5 to 10% of patients with complete AV septal defects have such abnormal AV valves that long-term competence may be impossible to obtain in this particular group. Nevertheless, continued refinement of surgical technique in conjunction with careful preoperative and intraoperative transesophageal echocardiography should hopefully decrease this incidence. Overall results with repair of complete AV septal defects has progressed remarkably over the last two decades utilizing both the single patch technique as described as well as with the two-patch repair.

References

1. Lillehei CW, Cohen M, Warden HE, et al: The direct vision intracardiac correction of congenital anomalies by controlled cross circulation. Surgery 38:11-29, 1955
2. Rastelli GC, Ongley PA, Kirklin JW, et al: Surgical repair of the complete form of persistent common atrioventricular canal. J Thorac Cardiovasc Surg 55:299-308, 1968
3. McMullan MH, Wallace RB, Weidman WH, et al: Surgical treatment of complete atrioventricular canal. Surgery 72:905-912, 1972
4. Trusler GA: Correction of type C complete atrioventricular canal: Surgical considerations [Discussion]. J Thorac Cardiovasc Surg 71:27, 1971
5. Crawford FA Jr., Stroud MR: Surgical repair of complete atrioventricular septal defect. Ann Thorac Surg 72:1621-1629, 2001
6. Capouya ER, Laks H, Drinkwater DC, et al: Management of the left atrioventricular valve in the repair of complete atrioventricular septal defects. J Thorac Cardiovasc Surg 104:196-203, 1992
7. Tweddel JS, Litwin SB, Berger S, et al: Twenty-year experience with repair of complete atrioventricular septal defects. Ann Thorac Surg 62:419-424, 1996
8. Mavroudis C, Backer CL: The two-patch technique for complete atrioventricular canal. Semin Thorac Cardiovasc Surg 9:35-43, 1997
9. Reddy VM, McElhinney DB, Brook MM, et al: Atrioventricular valve function after single patch repair of complete atrioventricular septal defect in infancy: How early should repair be attempted? J Thorac Cardiovasc Surg 115:1032-1040, 1998
10. Permut LC, Mehta V: Late results and reoperation after repair of complete and partial atrioventricular canal defect. Semin Thorac Cardiovasc Surg 9:44-54, 1997